Towards a tool to design vegetated strips for mitigation of pesticides transfers in surface runoff. Assessment of different scenarios.

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Introduction

Vegetated strips can be useful in order to limit the transport of pesticides from agricultural fields towards surface waters. However, as the efficiency of these structures is closely related to their ability to intercept incoming water, they need to be appropriately sited and of suitable size. In this paper, we assess the efficiency of vegetative strips to limit surface runoff in contrasting situations, representative of different parts of France.

Material and methods

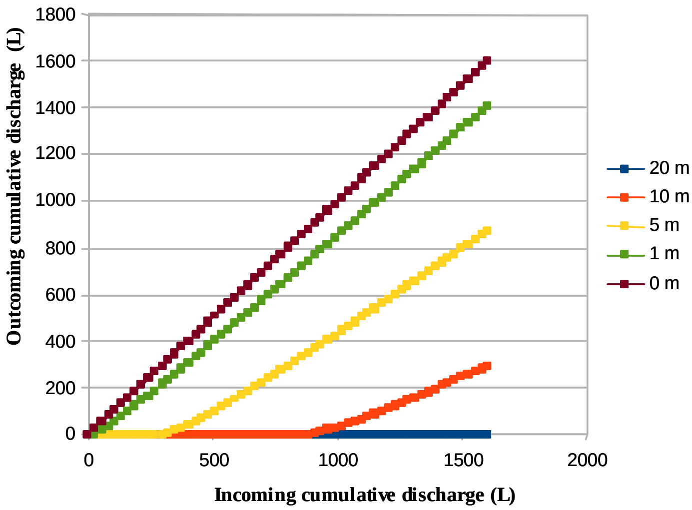
The modelling tool is a version of HYDRUS-2D (Simunek et al,1999) coupled with a kinematic wave equation, which represents both surface runoff and variably saturated flow in soil. Three agro-pedo-climatic situations were investigated: (**1)** La Morcille, in a vineyard area close to Lyon, with very permeable soils and intensive runoff events, (**2)** Le Pays de Caux, in the North West of France, where soils are very susceptible to hortonian overland flow because of surface crusting, and (**3)** La Jaillière close to Brittany, where soils are often hydromorphic. For each site, scenarios tested several conditions for the vegetative strip: slope (2, 7 and 15%), width (1, 5, 10 and 20 m), surface roughness (Manning coefficient of 0.05; 0.1 and 0.4 $s.m^{-1/3}$, i.e. going from very low to high roughness). For each combination of these parameters, typical summer and winter events were simulated, considering initial water status (particularly depth of the water table, when present) and the incoming runoff (intensity, duration).

Results

Vegetative strip behaviour can be described using a “double cumulative” curve, which plots cumulative outcoming runoff versus cumulative incoming runoff. For example, Figure 1 illustrates results for strips of respectively 1, 5, 10 and 20 metres width, in La Morcille, during summer conditions (deep water table, incoming flow of 1600 L/h for a width of one metre, during one hour). The point for 0 m corresponds to incoming flow; we can see that the wider the vegetative strip, the greater the attenuation of the incoming flow (roughly 1000 L for a 10 m wide strip). The slope of the curve, which remains lower than 1.0 even when outcoming runoff has begun (incoming flow exceeds infiltration capacity), shows that infiltration is still occurring It is important to note that this is no more true when the buffer zone is totally saturated (for example for “La Jaillière” in winter): then, once outcoming runoff begins, it is equal to incoming runoff (slope of the curve = 1.0), i.e. the efficiency of the buffer is limited to an initial “buffer volume”.
Results show significant contrasts between areas, depending in a major way on the mechanism which leads to runoff on the buffer surface, namely hortonian overland flow or runoff by surface saturation (water table rises to the surface, and no more infiltration occurs). In the first case (Pays de Caux and La Morcille in summer), the reduction of flow is significant, often greater than 50 %, even if it depends closely on

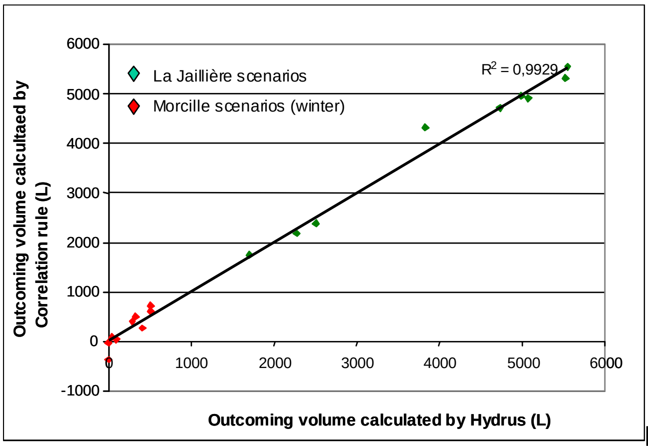
incoming flow intensity, such as in the case of Pays de Caux whose soils are crusted. In the second case, namely La Jaillière, the efficiency of the vegetated strip is very limited in winter. However, these findings have to be placed into context with the seasonal risk for a given area, taking into account the dominant crops and pesticide usage, before it is possible to make any firm conclusions on the actual efficiency of a vegetative buffer strip in a given context

Figure 1 : La Morcille, summer conditions, slope : 15% ; roughness : 0.2 s.m$^{-1/3}$.



Though results show global trends for each agro-pedo-climatic set of scenarios, they also provide evidence that it is essential to design each vegetative strip individually, taking into account local conditions. Based on the results, the most influential variables were identified and correlation rules were established. Correlation rules allow us to determine the relative efficiency of a vegetative strip to limit surface runoff, without a complete simulation, given its specific characteristics and the characteristics of the incoming runoff. We can see in Figure 2 that the coefficient of determination is very good for “saturation” cases (R^2 = 0.9929). In this case, the regression is based on the incoming water volume[D1], the strip’s width and the available volume of soil porosity [D2]at the beginning of the event.

Figure 2 : Outcoming volumes assessed by a correlation rule versus those simulated by Hydrus. Runoff arising from soil saturation (Jaillière ; Morcille in winter).



[D3]

References

Simunek, J., M. Sejna, et al. (1999). The HYDRUS-2D software package for simulating the two-dimensional movement of water, heat, and multiple solutes in variably-saturated media, International Groundwater Modeling Center, Riverside, California**:** 227 pp.